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Dichrostachyoxylon zirkelii (FELIX), Mimosoideae, a silicified wood from Miocene sediments of Küçük Çekmece Lake (Turkey)

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With 10 text-figures

Abstract

A fossil dicotyledonous wood has been collected in Miocene sediments during a field excursion in the European part of Turkey. The fossil is fairly well preserved and is attributed to *Dichrostachyoxylon zirkelii* (FELIX) MÜLLER-STOLL & MÄDEL 1967. Its anatomical structure is closest to some recent acacias *(Acacia catechu* WILLD.) and to *Dichrostachys cinerea* WIGHT & ARN. This suggests a dry climate period during the Miocene in Western Turkey.

Kurzfassung

Während einer im April 1989 im Auftrag der Bayerischen Staatssammlung für Paläontologie und historische Geologie durchgeführten Exkursion entdeckten die Teilnehmer Frau Dr. NERIMAN RÜCKERT-ÜLKÜMEN, Herr H. MERTEL und Herr F. HÖCK im europäischen Teil der Türkei ein verkieseltes Laubholz. Der jungtertiäre Holzrest gehört zur Familie der Mimosoideae (Ordnung Fabales) und wird aufgrund seiner erhalten gebliebenen Feinstruktur als *Dichrostachyoxylon zirkelii* (FELIX) MÜLLER-STOLL & MÄDEL 1967 bestimmt. Rezente *Dichrostachys*-Gehölze, niedere Bäume und Sträucher, wachsen auf trockenen Biotopen in Indien, Java, Australien und Afrika.

Contents

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1. Introduction

During a field excursion in special areas of the European part of Turkey, three members of the Bavarian State Collection, Munich, collected a fossil wood piece near Küçük Çekmece Lake (Fig. 1). The actual locality is situated about 800 m northwest of this lake. The yellowish-brown silicified wood, polished and unreeled by sandstorm or fluvial transport, was discovered on the surface between pepples and gravels. It shows a fairly good preservation of the minute structure and was found in Sarmatian sediments (personal information Frau Dr. NERIMAN RÜKKERT-ÜLKÜMEN, Munich). This fossil wood is deposited in the Bavarian State Collection, Munich.

A second fossil wood was discovered in August 1978 by Frau Dr. NERIMAN RÜCKERT-ÜLKÜMEN near Gürpınar (Fig. 1). Some pieces of this wood are also deposited in the Bavarian State Collection, Munich, Inventory-No. 1980 X 88. The main part of the big yellowish-white Miocene stemrest can be visited in the Geological Laboratory Maden Tetkik Arama, in the village of Corlu.

The nearly white and faded samples (7 slides), deposited in Munich, are not sufficiently preserved for detailed anatomical study. However, numerous mucilage cells in connection with the rays and other structural details, suggests that the fossil wood shows nearest resemblance with the modern wood of Lauraceae.

A third fossil wood from Turkey was found in Miocene sediments of Korkuteli, province Antalya (Fig. 1). The minute anatomy of this well-preserved wood has been described exhaus-

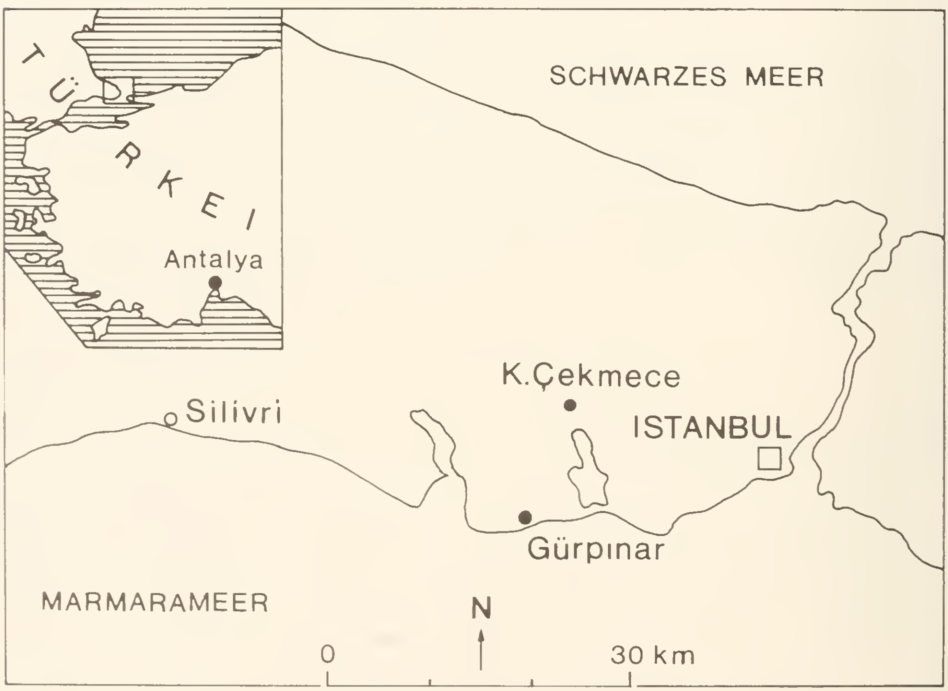

Fig. 1: Occurence of fossil woods in Turkey: Küçük Çekmece Lake (*Dichrostachyoxylon*, leg. 1989); Antalya (*Dichrostachyoxylon*, SAYADI 1973); Gürpınar (? Lauraceae; leg. 1978)

tively by Sayadi (1973) and shows a very close similarity with the fossil wood from Küçük Çekmece Lake.

2. A new system of anatomical description

The anatomical description of this fossil wood follows for the first time the "IAWA – list of microscopic features for hardwood identification" (Wheeler & Baas & Gasson 1989; IAWA: International Association of Wood Anatomists).

The "IAWA List" stimulates international exchange of information and experience on characters suitable for hardwood identification also in paleoxylotomy (paleobotany).

The list has 163 anatomical and 58 miscellaneous features, useful for identification purposes and is a valuable and modern guide and reference for descriptive wood anatomy and wood identification. The numbers assigned to each feature are not meant to be codes for a computer program, but are intended to serve for easy reference and to help translate data from one program or database to another.

In the following text the anatomical features are mentioned with the corresponding number in parenthesis (1–142). A database on fossil wood anatomical structure is in preparation, initiated by E. A. Wheeler, Department of Wood and Paper Science, North Carolina State University, Raleigh, USA.

3. The *Dichrostachys* wood of Küçük Çekmece Lake

Fabales (Leguminosae)

Family Mimosoideae

Dichrostachyoxylon zirkelii (Felix) 1967

Organgenus: *Dichrostachyoxylon* Müller-Stoll & Mädel 1967

Typusspecies: *Dichrostachyoxylon acaciaeforme* Müller-Stoll & Mädel 1967: 138–140, Abb. 10, Taf. 36, fig. 74–76.

Material: A fairly preserved silicified secondary dicurticated wood, colour brown-yellish, cut surface greyish-brown with little rostred stains, measuring 26 cm length, maximum 33 cm in diameter, weight 3,1 kg. The fossil and 5 slides are deposited in the Bavarian State Collection, Munich. The dimensions of the slides: 1 transverse section 3×3,5 cm, 2× tangential 1,7×2 cm and 2,8×1,7 cm, 2× radial 3,8×1,7 cm and 4×1,7 cm. – Inventory-No. BSP 1980 X 88.

Locality: About 800 m northwest of Küçük Çekmece Lake, European part of Turkey (Fig. 1).

Geological age: Upper Miocene, Sarmatien.

leg.: Dr. Neriman Rückert-Ülkümen, H. Mertel, F. Höck; Munich; April 1989.

3.1 Anatomical description

Diagnosis: Secondary dicotyledonous wood with the following microscopic features (IAWA List 1989):

1, 4, 5, 13, 22, 42, 47, 53, 60, 66, 70, 79, 81, 83, 89, 97, 104, 115, 136, 142.

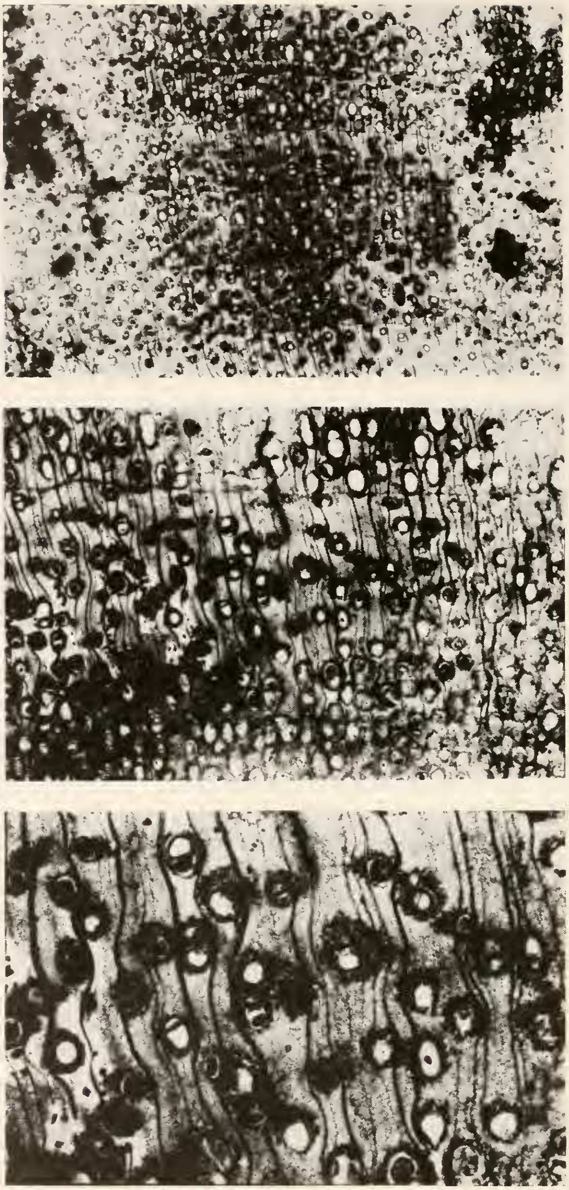

Fig. 2: Cross sections. Vessel distribution, growth ring boundaries and type of parenchyma pattern (a) ×6; (b) ×11; (c) ×24.

The anatomical description follows in sequence of the microscopic features (1–163), recommended 1989 by the IAWA Commitee (15 members of 9 different countries). The average density of vessels per unit area was determined by counting as an individual any vessel present, whether or not it occured as a solitary vessel or as one component of a radial multiple (Wheeler 1986).

Fig. 3: Cross section. Narrow growth ring with parenchyma in two marginal bands. ×50.

Fig. 4: Cross section. Growth ring boundarie with marked differences in vessel diameter between late wood and early wood of the following ring. ×50.

Fig. 5: Cross section. Axial parenchyma vasicentric and partly confluent, vessels with dark contents. ×50.

Fig. 6: Cross section. Rays, axial parenchyma confluent, thickwalled fibres. ×133.

Growth rings

Growth ring boundaries appear distinct, partly indistinct. On microscopic level growth ring boundaries are marked by differences in vessel diameter between latewood and earlywood and terminal or initial marginal parenchyma bands (feature **1**).

Indistinct growth ring boundaries between about 6 narrow rings, perhaps in consequence of pre-mineralisation shrinkage and more evenly distributed vessels (Fig. 2b; see below). Data on growth rings in sequence: 2,1 – 4,5 – 1,8 – (1,3) – (0,7) – (1,3) – (1,4) – (0,8) – (0,9) – 2,8 – 3,9 – 2,9 – 1,7 – 1,8 – 1,4 – 1,4 – 1,9 – 0,9 – 0,7 – 1,2 mm, medium 1,77 mm.

Vessels

The vessels in the early wood of the wide annual rings distinctly larger than those of the latewood of the previous growth ring (Fig. 2a, b; Fig. 4). Here the wood is semi-ring-porous (**4**). In some narrow growth rings the vessel distribution is nearly diffus-porous (**5**), (Fig. 3). Vessels solitary an radial multiples of 2 – (3), outline of the vessels circular to oval.

Perforation plates simple (**13**), intervessel pits alternate (**22**), ca. 5 μm (Fig. 8); due poor preservation further details as vessel ray-pitting absent.

Vessel tangential diameter of solitary vessels in the early wood (30 vessels in transverse section) 107–230 μm (164 μm), solitary vessels in the late wood 49–101 μm (79 μm), mean tangential diameter together along a radial transect through a growth ring about 125–135 μm (**42**).

Vessel diameter of radial multiples of 2 (radial × tangential) e. g.: 173×82 μm, 173×107 μm, 173×123 μm, 388×206 μm.

Fig. 7: Cross section. Axial parenchyma surrounding or to one side of the vessels, partly with lateral extensions forming a diamond-shaped outline. ×133.

Vessel diameter of radial multiples of 3 (radial × tangential) e. g.: 248×123 μm, 280×107 μm, 322×198 μm, 388×206 μm, 390×181 μm.

Vessels per square millimetre 5–19, mean value 11 (feature **47**), solitary vessels 43% (method: E. A. Wheeler 1986: 73–74).

Vessel element length 234–680 μm (mean 429 μm), (**53**).

Brown and dark plugs in many vessel elements (Fig. 2–7; Fig. 9a).

Tracheids and fibres

Vascular or vasicentric tracheids (**60**) occur in association with vessel elements. Helical thickenings of the tracheids can be observed (Fig. 9a). The inclination angle is nearly horizontal to steeply inclined, the helical thickenings are more coarse than fine.

The fibres are irregulary distributed, not in radial rows. Wall pitting of the fibres cannot be observed, only nonseptate fibres are present (**66**). Fibres lumina almost completely or nearly closed (Fig. 6–7), fibres very thick-walled (**70**). There is no change in the thicknes of the fibres between late and early wood.

Axial parenchyma

Paratracheal vasicentric (**79**), tendency to lozenge-aliform (**81**), partly confluent (**83**), all parenchyma cells differ from the ground tissue by dark contents (Fig. 2–7). Parenchyma also independent of the vessels in marginal or seemingly marginal small bands, (**89**). Parenchyma bands, straight or a little wavy, form a more or less continuous layer at the margins of a growth ring (Fig. 2b; Fig. 3–4).

Fig. 8: Tangential section. Intervessel pits alternate and minute. ×520.

Fig. 9: Radial section. Vascular tracheids with helical thickenings, vessel with dark contents (a) ×260; Tangential section. Rays 1–2 seriate, all ray cells procumbent. (b) ×155.

Rays

Ray width (1) – 2 – 3 cells (**97**), ray height not over 1 mm, only 116–539 μm (mean 299 μm); all rays cells procumbent (**104**), 9 – 11 – (14) rays per mm, (**115**), (Fig. 9b).

Prismatic crystals

Some rests of prismatic crystals or possible crystal moulds present (**136**), located in chambered axial parenchyme strand cells (**142**). The parenchyma strand cells are subdivided by thin cell walls (Fig. 10) chambered axial parenchyma cells partly abundant, cells vertical 15–20 μm, radial 28–32 μm; somtimes 2 upristh strands in contact (Fig. 10).

a b

Fig. 10: Radial sections. Subdivided, chambered parenchyma cells, prismatic crystals not preserved in this part of the slide. (a) ×210; (b) ×380.

3.2 Affinities

Literature: Barefoot & Hankins (1982), Carlquist (1988), Kribs (1968), Metcalfe & Chalk (1950, 1985), Miles (1978), Moll & Janssonius (1918), Normand (1950), Prior & Alvin (1983), Pearson & Brown (1932), Wagenführ (1989), Wagenführ & Scheiber (1985).

Xylothec: Institut für Holzforschung der Universität München: *Dichrostachys nutans* (6808) and (1619), *Guibourtia coleosperma* (2993), *G. ehie* (1432), *Hardwickia binata* (241), *Hymenaea courbaril* (574, 1288, 1299, 1300).

From a detailed comparison of the fossil wood with thin sections of the Xylothec, published descriptions and illustrations all features collectively indicate that the present fossil belongs to the family Leguminosae.

There is a close agreement in almost all details with *Dichrostachys nutans* (6808) and *D. cinera* (Moll & Janssonius 1918: 169–175, Fig. 167), partly with *Acacia-*, *Guibourtia-*, *Hardwickia-* and *Hymenaea*-species (more details see Privé-Gill 1985: 216–218).

Considerable studies has been carried out by Privé (1969) and Privé-Gill (1985: 218–220) to compare the minute anatomy of all described fossil *Dichrostachyoxylon*-woods (1969: 200–202; Tableau comparativ). Two silicified *Dichrostachys*-woods from the Upper Freshwater Molasse (Upper Miocene) of Southern Germany (Selmeier 1986, 1988) have nearly the same anatomical structure as the fossil wood from Küçük Çekmece Lake. Differences in the minute anatomy may represent different parts of the individual, like stem, twig or root.

The two fossil woods from Küçük Çekmece Lake and from Antalya (Sayadi 1973) have nearly identical minute structure. Descriptions of wood structure often include information on the number of vessels per square mm. But it is more than one way to count vessels per unit aerea (Wheeler 1986). The number of solitary vessels differs between 73 % (Sayadi 1973) and 43 % by the fossil wood from Küçük Çekmece Lake. Probably Sayadi (1973) has counted the solitary vessels by another method than is usual today. In future it is most important that any publication should clearly state which method was used.

Microscopic features of the fossil *Dichrostachys* woods from Antalya (Turkey; Sayadi 1973) and Küçük Çekmece Lake (Turkey; European part).

Locality	Antalya	Küçük Çekmece Lake
Age	Miocene	Sarmatien
Growth rings	present	20; 0,7–4,5 mm
Vessels	semi-ring-porous, solitary (72%) and 2–3,	semi-ring-porous, solitary (43%) and 2–3,
Diameter		
early wood	106–158 μm (128 μm)	107–230 μm (164μm)
late wood	80 μm	49–101 μm (79 μm)
Pits	alternate, 4–6 μm	alternate, ca. 5μm
Perforation	simple	simple
Length	177–272 μm	mean 429 μm, (234–680 μm)
vessels/mm^2	8–10	5–19, mean 11
brown-dark contents	present	present, abundant
Tracheids	–	present
Fibres	nonseptate	nonseptate, thickwalled
Parenchyma	paratracheal vasicentric, partly confluent, tendency to aliform, brown contents	paratracheal vasicentric partly confluent, tendendency to aliform brown-dark contents
Rays		
width	(1) – 2 – 3 – (4)	(1) – 2 – 3
height	< 500 μm	mean 299 μm, (116–539 μm)

composition	homogen	cells procumbent
per mm	17–20	9 – 11 – (14)
Prismatic crystals	–	axial chambered parenchyma cells abundant, partly with crystal rests

4. Growth ring characteristics

The analysis of growth rings in pre-Quaternary wood samples is proving to be of considerable use in interpreting palaeoclimate (Spicer & Parrish 1990).

The transverse section of the present silicified wood shows about 20 growth rings with (1) moderate to high variability in ring width, suggesting variable growth conditions from year to year and (2) partly wide rings (3,9–4,5 mm) suggesting favourable conditions during the growing seasons. Characteristics of growth rings for studying climatic signals are (a) ring width, (b) interannual variability in ring width, (c) proportion of late wood to early wood, (d) presence or absence of false rings (Spicer & Parrish 1990: 232).

The data set of 20 growth rings, range 0,7–4,5 mm (medium 1,77 mm) is to small for conclusions about climatic conditions. However, different growing conditions within the twenty years are probably. Growth rings of 3–4,5 mm are regarded as indicative of favourable conditions during the growing season (warmth, water, enough light for assimilation, mineral absorption through roots). Supposing, discontinuous and/or false rings are present in the petrified wood of Küçük Çekmece Lake (Fig. 2b; see below), they indicate perhaps extreme drought, insect attac or fire.

No comprehensive analysis of the ring width variability of all silicified *Dichrostachys* woods is available. Until today the anatomical structure is known from about 15 tertiary *Dichrostachyoxylon* species, localities distributed in North America, Europe and Turkey (specification: Privé 1969: 200–202; Selmeier 1988: 136–137). How the different growth factors play a role in the annual sequence of *Dichrostachyoxylon* fossils remains to be investigated.

5. Charred wood of *Dichrostachys cinerea* (L.)

It is well known that charred wood usually retains its gross features sufficiently for generic identification. Charcoals are sometimes a useful paleoclimatic indicator (Schweingruber 1988). Secure identifications of taxa in each archeological assemblage are essential (Selmeier 1964, 1988). Only few studies have been concerned with the objective determination of the structural changes which occur as a result of charring (Prior & Alvin 1983: 197).

Samples of mature wood from *Dichrostachys cinerea* were charred for 60 minutes at a range of temperatures from 300 to 800°C (Prior & Alvin 1983). No gross structural changes occur in the parenchyma. Chambered parenchyma containing prismatic crystals is a conspicuous and constant feature of the wood. Specimen charred showing some crystals still present (Prior & Alvin 1983, Fig. 11). The crystals are remarkably present up to 700°C.

Crystals in subdivided parenchyma cells or rests of them, survived also in silicified woods million of years (Crawley 1988, Fig. 16) and are still present in the following 7 petrified wood samples of *Dichrostachyoxylon* species from different localities in North America, Europe and Asia (Turkey):

D. occidentale (PRAKASH & BARGHORN)	USA	MÜLLER-STOLL & MÄDEL 1967
D. zirkelii (FELIX)	Hungary	MÜLLER-STOLL & MÄDEL 1967
D. aff. *zirkelii* (FELIX)	Turkey	SAYADI 1973
D. zirkelii (FELIX)	France	PRIVÉ-GILL 1985
D. aff. *zirkelii* (FELIX)	Germany	SELMEIER 1986
D. zirkelii (FELIX)	Germany	SELMEIER 1988
D. zirkelii (FELIX)	Turkey	Fossil wood of Küçük Çekmece Lake

6. Ecology

Dichrostachys is a fairly small and mainly tropical genus of the Old World. The name *Dichrostachys* is based on Greek words meaning "two-coloured flowers". The steril flowers in the lower part of the tree are pinky-mauve or purple, the bisexual flowers on the upper part are yellow.

Dichrostachys cinerea (L.) WIGHT. & ARN., subsp. *africana* (= *D. glomerata, D. nutans)* and subsp. *nyassana* are widespread species reaching from the dry parts of Natal and the Transvaal, Botswana and South West Africa, northwards to tropical Africa, eastwards to India and Australia.

Generally, *Dichrostachys* is a small tree or shrub, easily mistaken for an acacia, with a twisted, deeply fissured stem, seldom more than 23 cm in diameter. The termite-proof wood, almost imperishable, is very hard and dark. The tree grows on flats, sometimes on low hills and along stream banks, in thornveld and mixed woodland *(Dichrostachys-Acacia* Veld, a distinct veld type of the Arid Sweet Bushveld in Africa).

Biotops in Asia: Dry stony hills in Central India, Rajputana and the Deccan, dry regions of the middle Irawadi valley (BRANDIS 1906: 261); dry regions on heavy poor soil, brushwood, hedges, teak-forests, lalang fields in Java (BACKER & BACKHUIZEN 1963: 562); dry scrub forests and stony hills in India (GAMBLE 1967: 297).

The distribution of the genus *Dichrostachys* in Asia and Africa covers a wide climatic diversity. However, we are in position to draw at least tentative conclusions regarding the ecologic conditions which appear to have existed for *Dichrostachys* during the miocene: annual middle temperature 15–25°C, minimum of annual precipitation 250–700 mm (PRIVÉ 1970: 203).

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The author wishes to thank Dr. NERIMAN RÜCKERT-ÜLKÜMEN, Munich, for all informations about the discovery of two fossil woods in the European part of Turkey. Skillful preparation of the slides by H. MERTEL, drawing of the map by K. DOSSOW, processing of the fotos by

F. Höck. Thanks also to Dr. D. Grosser, Institut für Holzforschung, University of Munich, for facilities to consult the Xylarium.

Mme. Dr. C. Privé-Gill, Université de Paris–VI, Laboratoire Paléobotanique, has made available the French publication by S. Sayadi (1973).

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